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BURN OR BALE: EFFECT ON BIOMASS AND NUTRIENTS

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Introduction

Burning has been used for years to reduce residue after harvest. The rationale is that seeding equipment cannot be effective when large amounts of residue remain on the soil surface. Albrecht et al. (1995) reported that burning volatilized 65 percent of the stubble biomass. They speculated that 65, 36, 26, 6, and 6 percent of carbon (C), nitrogen (N), sulfur (S), phosphorus (P), and potassium (K), respectively, would be lost during the burn. When residues are burned, approximately 60 percent are lost as carbon dioxide (CO_2) immediately, leaving only 40 percent to be oxidized by soil microorganisms. Thus, when a field is burned, only 8 percent of the residue can be incorporated into SOM. Also, burned stems and grain kernels are less biologically active in soil than unburned residue, and may not be viable energy sources for soil microorganisms (Albrecht et al., 1995). It has long been known that burning is deleterious to SOM (Biederbeck et al., 1980; Rasmussen et al., 1980). Burning also removes the residue cover on the soil required to help control soil erosion on sloping land.

Several industries utilize wheat straw offsite. The dairy industry uses wheat straw as bedding material for animals, and mushroom growers use straw as a nutrient source. Recently, a number of companies have evaluated the use of wheat straw as a component of particleboard. There are now production plants in Australia, England, and the U.S. where wheat straw, sugar cane bagasse, and rice straw are being used as the primary ingredient in particleboard plants. One firm indicates they plan to use 60 tons of straw per day and up to 25,000 tons per year to produce particleboard (Confederated Umatilla Journal, 1998). Another firm is using 50 tons of wheat straw annually to produce strawboard used in building and furniture construction (East Oregonian, 1999).

Objectives of this research are to evaluate the potential differential effects on the amount of C, N, P, K, and S left in a field after burning, baling, or non-removal of straw.

Materials and Methods

Twenty-one combines, each making at least two passes, were evaluated for residue distribution in 15 wheat fields (Allmaras et al., 1985). Before each combine pass, two bundles of wheat were cut at ground level from a 16.2-feet-square area for determination of nutrient distribution (Douglas et al., 1992). Average straw height (minus heads) in the 15 fields was 36 inches. Thirty culms were separated from each bundle and weighed. Heads were removed and straws were dissected into 4-inch sections from the ground surface. Four-inch sections from each straw were combined to give a 30-straw weight for each 4-inch section, up to 36 inches. This gave nine 4-inch sections for each 30 straws. Combined sections were analyzed for nitrogen by automated analysis after Kjeldahl digestion (Nelson and Sommers, 1973). Phosphorus and potassium were determined colorimetrically, on an Alpchem autoanalyzer (Kitson and Mellon, 1944), and by atomic absorption analysis (Isaac and Kerber, 1971), respectively. Sulfur was determined turbidimetrically after percholoric acid digestion (Blanchar et al., 1965).

Results and Discussion

Table 1 gives average biomass and nutrient contents of wheat straw across Agronomic Zones (AZ) in the Pacific Northwest (PNW) (Douglas et al., 1990). In general, precipitation decreases from zone 2 through zone 4. Precipitation is the same in zone 4 and zone 5, but the soil is shallower (less than 3 feet deep) in zone 4 than in zone 5(greater than 3 feet deep), and zone 6 is irrigated. Agronomic zone 1 is not discussed, because generally soils in this zone are too cold or too shallow for cultivation, and only about 10 to 15 percent is cultivated. However, if wheat were grown in zone 1, yields would be approximately the same as zone 5. There were no fields sampled in zones 3 and 4; therefore, grain yields were estimated for these zones. Residue biomass was assumed to be 100 pounds for each bushel of yield in all zones. Carbon was assumed to be 42 percent in all residues. Nutrient values are calculated using actual values determined from straw samples from zones 2, 5, and 6. Values given in Table 1 are the amounts of C and nutrients returned to the soil, providing all residue is not burned or otherwise removed.

Table 2 compares biomass and nutrients removed from each AZ if straw either is baled or burned. In general, nutrient concentrations in straw increase from the ground surface to the top of the wheat stem (data not shown). Average stubble height after harvest in the 15 fields, across all AZ, was 16 inches. All vegetative parts of the plant above the cutter bar height (average of 16 inches in the 15 fields evaluated) go through the combine and are distributed, usually unevenly, within the standing stubble. Much of the stem above 16 inches is not baled and removed, because it falls to the ground within the stubble. The standing stubble is cut approximately 4 inches high and windrowed to prepare for the baler. Producers report that approximately 50 percent of above ground residues are left after baling. Therefore, in order to make residue removal equal 50 percent of total residue prior to baling, straw removed includes stubble from 4 to 16 inches, plus that part of the straw above 16 inches that went through the combine during harvest. The fraction of each nutrient in each 4-inch section above 16 inches was multiplied by the total nutrient in these sections and summed. Half of this sum was added to the sum for the 4- to 16-inch sections and subtracted from the sum of the stem sections above 16 inches to equate to 50 percent residue retention.

In general, baling removes approximately the same amount of N and S but more P and K than burning (Table 2). However, more nutrients can be lost if wind or water removes ash after burning. Average N, S, P, and K removed from a field by baling is 36, 35, 42, and 39 percent and burning 35, 26, 6, and 6 percent, respectively, of the total nutrients present in wheat straw. However, burning removes more straw biomass, and thus C, than does baling.

Table 1. Average biomass and nutrient contents in straw for agronomic zones of the dry-land wheat growing areas of the Pacific Northwest.

Measured Parameter	Agronomic Zones[†] 2	3	4	5	6
	Pounds/Acre				
Residue[‡]	8,390	8,000	4,000	8,100	15,961
Carbon	3,524	3,360	1,680	3,400	6,704
Nitrogen	34	26	11	24	97
Sulfur	6	4	2	3	26
Phosphorus	4	3	1	3	21
Potassium	116	82	32	74	356

[†] Agronomic Zones from Douglas et al., 1990. Agronomic zone 1 was not included, as only 10 to 15 percent of this zone is cultivated.

[‡] Yields were estimated to be 80 and 40 bushels per acre for agronomic zones 3 and 4, respectively.—Residue was assumed to be 100 pounds per bushel grain yield. Residue carbon was assumed to be 42 percent. Nutrient values are calculated from 10-cm straw sections from 15 fields across all agronomic zones 2, 5, and 6.

Table 2. Comparison of biomass and nutrients removed by baling or burning.

Measured	Agronomic Zones[†] 2		3[‡]		4		5		6	
Parameter	Bale	Burn[§]	Bale	Burn	Bale	Burn	Bale	Burn	Bale	Burn
	Pounds/acre									
Biomass	4,195	5,454	4,000	5,200	2,000	2,600	4,050	5,265	7,980	10,375
Carbon	1,762	2,291	1,680	2,184	840	1,092	1,701	2,211	3,352	4,358
Nitrogen	11.8	12.1	11.8	9.2	5.0	4.0	8.6	8.8	37.7	35.1
Sulfur	2.4	1.7	1.8	1.1	0.6	0.4	1.2	0.8	11.0	6.7
Phosphorus	1.1	0.2	1.4	0.2	0.6	0.1	0.9	0.1	7.7	1.3
Potassium	50.5	7.0	40.9	4.9	16.0	1.9	30.8	4.4	142.4	21.4

[†] Agronomic Zones from Douglas et al. (1990).

[‡] Yields were estimated as 80 and 40 bushels per acre for zones 3 and 4.

[§] Assumed 100 pounds of residue per bushel of grain yield. Assumed burning removed 65, 65, 36, 26, 6, and 6 percent of biomass, carbon (C), nitrogen (N), sulfur (S), phosphorus (P), and potassium (K), respectively (Albrecht et al., 1995).

More residues are left on the soil surface when residue is baled than when it is burned. Increased surface residue equates to increased erosion control, increased C input into SOM, and increased potential to maintain or increase SOM. Research on long-term plots in Pendleton indicates it takes approximately 4,300 pounds of wheat residue per acre per year to maintain SOM (Rasmussen et al., 1980). Larson and coworkers (1972), found it required approximately the same amount of corn residue (4,300 lb/a/yr) to keep SOM stable in Iowa. These results suggest that independent of location or climate, residue required to maintain a stable SOM content is constant. Table 3 gives the amount of residue left on fields in each AZ after baling or burning. If 4,300 pounds of residue per acre per year is required to keep SOM stable, then baling residue from annual cropped fields in zones 2 and 6 and possibly zone 3 will leave enough residue to maintain SOM. Burning leaves less than 4,300 pounds of residue per acre in all zones except zone 6, even if fields are annual cropped. Wheat/fallow systems result in one crop every 2 years; therefore, the data for baling in Table 3 must be decreased by 50 percent. Thus, baling or burning in wheat/fallow systems would result in annual residue returns much lower than required to maintain SOM. Wheat/fallow is the norm in zone 4, zone 5, and often zone 3, which makes removal of residue by both baling and burning extremely undesirable in these zones.

Table 3. Residue left after baling or burning.

	Agronomic Zones				
Residue	2	3	4	5	6
	------------------------------Pounds/Acre------------------------------				
Total	8,390	8,000	4,000	8,100	15,961
Bale	4,195	4,000	2,000	4,050	7,980
Burn	2,936	2,800	1,400	2,835	5,586

Summary

Baling removes an average of 36, 35, 42, and 39 percent of the N, S, P, and K, respectively, present in residue in all AZ in the PNW. Burning removes approximately the same percentage of N and S but less P and K than baling. Baling removes fewer residues and therefore less C than burning. Thus, if approximately 50 percent of residues in the field are removed by baling, burning has the potential to decrease SOM more than does baling. Only zone 6, and possibly zones 2 and 5, produce enough residue to allow the removal of 50 percent of the residue by baling and still have enough left to stabilize SOM.

However, this is true only in an annual cropping system. If wheat/fallow were the system of choice, the amount of residue left after either baling or burning would not be sufficient to stabilize SOM in any agronomic zone. If residue reduction were required, baling would be preferred over burning in all agronomic zones in the PNW. Baling would leave more residues on the soil surface, which gives a better potential for controlling soil erosion and for maintaining or increasing SOM, and does not have many of the negative environmental effects of burning.

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